Name ____ AP Chemistry

Energy & Heat/Work

Thermodynamics is the study of energy and its interconversions, or changing form, and the *first law of thermodynamics* states the law of conservation of energy. The *law of conservation of energy* says that energy can be converted from one form to another but can be neither created nor destroyed. There are multiple forms of energy: potential energy, kinetic energy, etc. Basic definition of energy and the forms:

- Energy

- Potential energy

- Kinetic energy

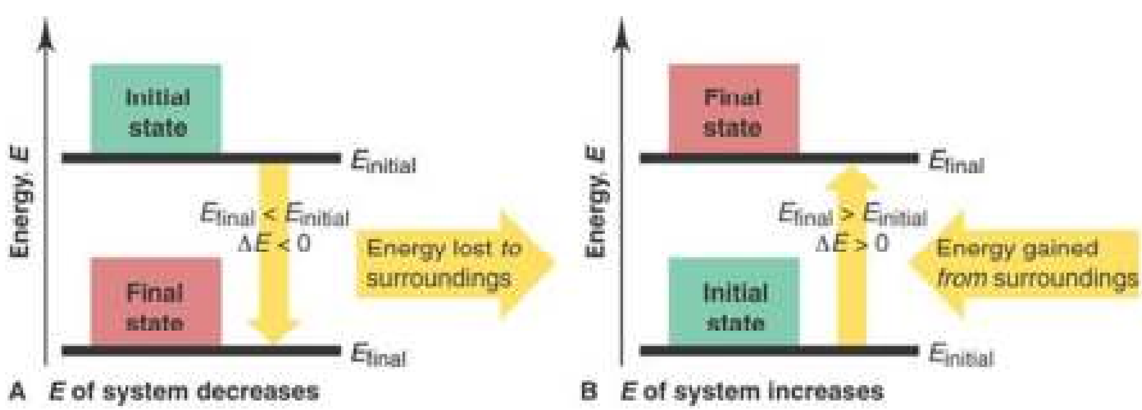
Energy is a *state function*, which is a property that does not depend on the path between two states. However, heat and work are not state functions so they depend on the pathway. For further explanation, imagine a trip from Chicago to Denver. The mileage will change based on the way that you travel from Chicago to Denver. However, the elevation will change the same amount regardless how you go from one city to the other. The elevation is similar to energy and other state functions while mileage is like heat or work.

Another example of energy is chemical energy, or energy surrounding a chemical reaction. The chemical reaction and universe it is in can be divided into two parts: system and surroundings.

- System

- Surroundings

Different terms are used to describe the movement of energy. *Exothermic* is when energy is released while *endothermic* is when energy is put into a reaction.



Energy is measured in terms of work and heat within a system. The complete energy, both potential and kinetic energy, is known as the *internal energy*. This internal energy can be changed by a flow of work, heat, or both. Basic definitions of heat and work and relationship to internal energy:

- Heat

- Work

Heat and work not only have a value but a sign associated with them. Heat is negative if heat is leaving the system while positive heat means that heat is moving into the system. For work, w is negative when the system is doing work on the surrounding (energy is flowing out of the system). W is positive when the surroundings are doing work on the system (energy is flowing into the system. All of these signs are assigned from the system's prospective.

Example #1:

Calculate the ΔE for a system undergoing an endothermic process in which 15.6 kJ of heat flows and where 1.4 kJ of work is done on the system.

Work can also be related to pressure and volume, based on the definition of pressure, with the following relationship:

Example #2:

A balloon is being inflated to its full extent by heating the air inside it. In the final stages of this process, the volume of the balloon changes from 4.00×10^6 L to 4.50×10^6 L by the addition of 1.3×10^8 J of energy as heat. Assuming that the balloon expands against a constant pressure of 1.0 atm, calculate ΔE for the process. (To convert between L·atm and J, use 1 L·atm = 101.3 J)

Questions:

1) A system undergoes a process consisting of the following two steps:
   Step 1: The system absorbs 72 J of heat while 35 J of work is done on it.
   Step 2: The system absorbs 35 J of heat while performing 72 J of work.
   Calculate ΔE for the overall process.

2) Calculate ΔE, and determine whether the process is endothermic or exothermic for the following cases:
   (a) A system absorbs 85 kJ of heat from its surroundings while doing 29 kJ of work on the surroundings.
   (b) $q = 1.50$ kJ and $w = -657$ J
   (c) The system releases 57.5 kJ of heat while doing 13.5 kJ of work on the surroundings.

3) A sample of an ideal gas at 15.0 atm and 10.0 L is allowed to expand against a constant external pressure of 2.00 atm at a constant temperature. Calculate the work in units of kJ for the gas expansion. (Hint: use Boyle's law)

4) Consider a mixture of air and gasoline vapor in a cylinder with a piston. The original volume is 40 mL. If the combustion of this mixture releases 950 J of energy, to what volume will the gases expand against a constant pressure of 650 torr if all the energy of combustion is converted into work to push back the piston?